9.

Comparative Biology of Salticid Spiders at Rancho Grande, Venezuela. Part II. Methods of Collection, Culture, Observation and Experiment.[1]

JOCELYN CRANE.
Research Zoologist, Department of Tropical Research.
New York Zoological Society.

[This is one of a series of papers resulting from the 45th, 46th and 47th Expeditions of the Department of Tropical Research of the New York Zoological Society, made during 1945, 1946 and 1948 under the direction of Dr. William Beebe, with headquarters at Rancho Grande in the National Park of Aragua, Venezuela. The expeditions were made possible through the generous cooperation of the National Government of Venezuela and of the Creole Petroleum Corporation.

[The characteristics of the research area are in brief as follows: Rancho Grande is located in north central Venezuela (10° 21′ N. Lat., 67° 41′ W. Long.), 80 kilometers west of Caracas, at an elevation of 1,100 meters in the undisturbed montane cloud forest which covers this part of the Caribbean range of the Andes. Adjacent ecological zones include seasonal forest, savanna, thorn woodland, cactus scrub, the fresh water Lake Valencia, and various marine littoral zones. The Rancho Grande area is generally subtropical, being uniformly cool and damp throughout the year because of the prevalence of the mountain cloud cap. The dry season extends from January into April. The average humidity during two expeditions, including parts of both wet and dry seasons, was 92.4%; the average temperature during the same period was 18° C.; the average annual rainfall over a 5-year period was 174 cm. The flora is marked by an abundance of mosses, ferns and epiphytes of many kinds, as well as a few gigantic trees. For further details, see Beebe & Crane, *Zoologica*, Vol. 32, No. 5, 1947.]

CONTENTS.

I. INTRODUCTION.

The following pages describe the general methods of working with jumping spiders at Rancho Grande, Venezuela. Although some of the field techniques are axiomatic to experienced arachnologists, they are included here for completeness, since they may be helpful to new students of the group, or to those who have not worked in the tropics.

Part I of this series dealt with systematics and life histories in *Corythalia*, excluding experimental work (Crane, 1948). The applications and results of the techniques outlined in the final section of this paper will be reported in future publications. All of the experimental salticid work at Rancho Grande has been concerned with a comparative study of the innate releasing mechanisms of the epigamic displays in various genera. The ultimate aim is two-fold: first, to work out evolutionary patterns within the family, with particular attention to the relationships between function and structure; second, to compare and correlate the mechanisms in this family with those in unrelated groups, in accordance with the stimulating work of Lorenz, Noble, Lack, Tinbergen and their associates, who have been concerned almost exclusively with vertebrates (e.g., see Tinbergen, 1948, with bibl.).

The study of living salticids is one of the most continuously fascinating and ultimately rewarding of zoological pursuits. Nevertheless, the pioneering Peckhams were quite right when they warned enthusiastic readers, some sixty years ago, against going in for such a study casually. Deep appreciation is due them and all the more recent students of live salticids, including particularly Bristowe, Bonnet and Kaston, who, working patiently in the brief northern summers, have recorded and studied many salticid displays.

The tropics have the great advantage of leisurely seasons combined with large numbers of species. Nevertheless, just as in the north, it is essential to be on familiar terms with the local forms, with their restricted niches, relative abundance and specific idiosyncracies. Also, it is most important to remain in a single locality for as many months of as many years as possible: tropical salticids, although they may be carried north successfully, have their innate rhythms disturbed, becoming irregular in their moults and erratic in activity after the trip.

In some ways tropical salticids are ideal experimental animals. The variety of behavior and correlated structures in closely related forms makes them of peculiar interest in the study of basic evolutionary problems. They are, under proper conditions, exceedingly hardy. Their food supply is usually easily arranged. Individuals have an active

[1] Contribution No. 816, Department of Tropical Research, New York Zoological Society.

adult life of at least one month and usually two or more. The breeding seasons of most species extend over months, and sometimes throughout the year. Most important, these spiders are extremely adaptable to captivity, and adequate comparative observations in both field and laboratory indicate no differences whatever in basic behavior patterns.

Nevertheless, rearing and experimenting with salticids is a finical business. Although the adults are giants compared to *Drosophila*, they are pygmies to a guinea pig, and any trainer of jumping fleas would feel more promptly at home with them than a gifted researcher accustomed to monkey and mice. Rare or experimentally important spiders escape, get squashed or eaten, and inexplicably die at the most inopportune moments. Cloud forest species may be killed in a night if moisture is withheld; xerophytic forest forms can die in three days through too much humidity. An extra whiff of chloroform during some simple operation may ruin forever the future display performance of a valuable male. A rare and delicate female, reared, mated, fed and tended with difficulty through half a year, to secure an evolutionarily significant first instar, ultimately laid nothing but three bad eggs.

Not the least of the exasperations of behavior students in tropical localities is the fact that most salticids turn out to be little known or altogether new, necessitating a great deal of fundamental taxonomic work. Two exceptional neotropical regions are Panama and the West Indies, their spider fauna having been clarified in the excellent recent reports of Chickering (e.g., 1946) and Bryant (e.g., 1943), respectively.

Genetical work is greatly needed in the group and is almost an untouched field. As subjects, however, salticids are only moderately suitable. Few species so far tested breed reliably in captivity. The usual length of a generation averages perhaps six months, and so is too long to be convenient. The broods are small, the total number of eggs laid by a female of average size in many genera never reaching more than thirty, and sometimes numbering less than ten. To rear to maturity even four or five young of a given brood has so far been accomplished only several times at Rancho Grande, and second generation offspring of captive specimens have only been secured twice. However, these mechanical rearing difficulties are directly traceable to the fact that many species were under simultaneous observation, and that no stay in the laboratory was longer than six months; a geneticist who restricted his choice of work species with knowledge and care, and could keep the broods going continuously through, say, two years, would have results of great value.

Finally, any zoological investigator who is fortunate enough to pass sufficient time in a permanent tropical laboratory, will find a field of immense interest in salticid spiders, if he has an inclination for studying complex behavior and evolutionary problems in a relatively unfamiliar group. Although he will quickly work out his own improved techniques, the following suggestions may save him a number of time-consuming trials and errors.

II. Collecting Methods.

The principal collecting method was the shaking of bushes and branches into a large, inverted umbrella, the specimens being caught in vials as they ran up toward the rim. Because of the steep terrain and tangled, chronically damp vegetation around Rancho Grande, the umbrella method was more efficient and convenient than the equally popular systems of spreading a sheet under the foliage to be shaken, or sweeping the shrubs with a net. *Corythalia* and other primarily terrestrial forms were located by simple visual searching in the right habitats, and were secured in inverted vials, this method proving more effective for the surface-living jumpers than the sifting of leaves. A few salticids were collected on tree trunks and in epiphytic bromeliads. The latter were detached by our tree-climbing Venezuelan assistants, lowered carefully upright to the ground with a light rope, and either dissected over a poncho on the spot or wrapped up and brought intact to the laboratory.

Salticids wanted for study alive should never be risked in the same vial with any other spider, even though their sizes appear so nearly equal that there seems to be small danger of one's eating the other; different species and even individuals differ greatly in aggressiveness and voracity. The most convenient way of carrying a sufficient number of vials up and down mountains is in two light-weight cotton bags — snake-collecting bags are excellent—with drawstring tops; they can be slung over each shoulder, or hung at the belt. With empty vials in one bag and used ones in the other, there is neither delay nor confusion when a single umbrella-shake suddenly yields a half dozen much-desired and extremely agile jumping spiders.

Collecting during or soon after a rain is not rewarding, since salticids then cling their tightest or even go into their night-time shelters, and the water from the shaken leaves is likely to drown whatever spiders there are. Nevertheless, in choosing seasons for tropical collecting, the drier months should be avoided, since salticids are then often impossible to find in deciduous woods, scrub and savanna, and are relatively scarce even in rain and cloud forests.

The richest collecting areas for salticids in northern South America have always proved to be neglected clearings and the edges of forest roads or paths. The forests themselves are uniformly poor, as are open savannas. Unfortunately, no collecting has yet been done high in the forest canopy; that well-lighted niche should prove remarkably rich whenever an adequate system of arboreal locomotion can be devised.

Although many salticids live in the temperate zone, the display season is usually brief and the winter a period of inactivity. In contrast, the great majority of salticids are tropical, so that far more material is available to the student in low latitudes. More important for behavior studies, the tropical breeding season is always prolonged and sometimes, it seems, perennial, so that growth and display may be observed throughout the year in sufficiently humid localities.

III. Maintenance and Culture.

A number of excellent methods have been worked out for keeping various families of spiders alive in the laboratory, among which may be mentioned those of Bonnet (1930), Branch (1942) and Brown (1945). The salticids, however, have always proved difficult. The Peckhams (1889) reared one female salticid through ten molts, but she died before becoming mature. Wagner (1888) also had some success, but does not give details. Moles (1916) reared various families, but could not bring salticids through the early instars. Bonnet's first attempts to rear salticids failed, although he had great success with other groups; finally, however (1933), he reared a brood of *Philaeus regius* to maturity and was able to breed the resultant adults with each other.

The method described below is an adaptation of various techniques of spider and insect culture, and was necessitated both by the sensitivity of the spiders to drought and by the special conditions at Rancho Grande. High humidity was essential to these cloud forest spiders, while the laboratory was relatively dry; yet the spiders could not be kept in stoppered vials with moistened corks, because excessive mold often developed overnight.

The method which eventually proved successful was the following. It involved the care of an average stock of about 75 individuals, exclusive of first and second instar broods. All spiders, except mated pairs, were kept in individual cylindrical specimens jars, measuring 1½ × 2", 2¼ × 3" or 3 × 3½", depending on the size of the spider. The largest size was reserved for large mated pairs or for females with egg cases; individuals did not do better in ample space than in the minimum-sized jars assigned, and to save space and for convenience they were given the smallest size feasible. Strong, fine-mesh, khaki-brown mosquito netting, of regular army grade, was used for covers and secured by rubber bands. The most convenient jar labels proved to be a self-adhesive type put out by the Avery Adhesive Label Corporation of Los Angeles, California; pencilled data in regard to molts, etc., could be erased and changed repeatedly. The jars were kept on a special table near the laboratory windows, in excellent light but away from the direct sun. Jars of experimental adults were kept well separated, in order to avoid the effects of summation, reinforced stimuli and overstimulation before experiments, since some individuals display on a visual sign-stimulus alone, even through the distortion of two curved glass walls.

Each jar contained a small cylinder of cotton dental wadding 10 or 15 mm. long by about 6 mm. in diameter. This was saturated, although not to the dripping point, every two to four days. The optimum condition seemed to be that it should be practically dry before remoistening. The spiders could all stand prolonged fasting; some survived after several hours in the refrigerator and a few could withstand moderate heat; drought, however, killed all kinds rapidly.

The spiders were fed on *Drosphila* and other small flies several times a week. Since wild *Drosophila* and houseflies were practically absent at Rancho Grande, while small flies of other groups were abundant in the caretakers' cottages, only two or three jars of breeding *Drosophila* were maintained, and were used for emergencies only. Vials full of the other flies were easily captured at night, attracted to a flashlight from the cottage walls and ceilings where they roosted. The quickest feeding methods for our collections proved to be the following: a vial of flies was lightly chloroformed with a moistened cork and decanted onto white cardboard. About three to six flies were then brushed lightly into each jar, after the dental wad had been dipped in water. Where reared *Drosophila* were used, a large group was allowed to escape into a jar inverted over the breeding bottle, and a card with a chloroform-saturated bit of cotton slipped across the aperture; afterwards the stupefied flies were brushed as before into the spider jars. This proved simpler and faster than permitting the requisite number to escape directly into each jar through a small opening in the top of the fly bottle. The spiders became so tame that they were completely undisturbed by the routine. A light tap sent them away from the netting tops. The young, when about to molt, usually spent at least two or three days in their cocoons, never eating at this time; these were disturbed as little as possible, but the wad had to be dampened. Even when the cocoon was spun at the junction of netting and glass, a little care avoided injury. The jars were cleaned about every ten days.

Naturally there were frequent accidents and escapes, especially during transfers to and from observation dishes (see below). One source of trouble was the rubber bands which rotted quickly in the climate and tended to break without warning. Another was an occasional incursion of small ants, who scavenged among the dead flies in the jars, leaving tiny holes in the netting large enough for the escape of small spiders. In a lowland tropical laboratory, ants would be a real nuisance which, however, could easily be prevented by the time-tested custom of

standing table legs in kerosene or wrapping them in poisoned "ant tape." Major and unexplained pests were the mites which often appeared in egg cases. It now seems certain, however, that they attack only bad eggs or dead spiderlings; dead flies in the jars were never touched. Their method of dispersal is a puzzle; infected jars were always carefully cleaned before re-use.

Young spiders were usually removed from their mothers as soon as they emerged from the cocoon, although there was not a single case of cannibalism between mother and young, or between first or second instar spiderlings, in any of the salticids under observation. Two or three second instar spiders could be kept in a single small jar, but were usually segregated before the next molt. A few individuals of placid-tempered species were reared together almost to the adult stage.

No food is taken during the first instar, but is essential during the second. Incidentally, none of the tropical salticids studied spend more than the first instar in the cocoon. During the second, tiny live creatures from the leaf litter were given, collembola and minute worms being the most acceptable to small forms such as *Corythalia xanthopa.* This is the most crucial period of rearing and few individuals were brought through it. As soon as a spider had eaten one meal, it was ready to tackle a wriggling but de-winged *Drosophila,* even though the fly was always considerably larger than the spider. Larger species could seize de-winged *Drosophila* as their first food. Dr. Ernst Mayr and Dr. T. Dobshansky, in conversation, have made the sensible suggestion that a culture of wingless *Drosophila* mutants would be helpful in feeding the youngest specimens on a large scale. Before the second instar was over, the sturdiest individuals could catch normal *Drosophila,* and several *Corythalia chalcea* in one brood caught them as first food. Certain aphids were acceptable to the very young in emergencies, but were not good as a steady diet. I had no success in inducing young salticids to feed on freshly killed and punctured insects, since they never showed any interest in a motionless body (cf. Mole's successful rearing of other families by this method, 1916).

IV. Methods of Study and Experiment.

Color Records. It was essential to record colors from living specimens. The general aspect was described from non-anaesthetized examples in vials under a binocular microscope. Details of scalation were recorded after a specimen was chloroformed. Variations proved to be so great in some species that it was essential to make complete descriptions of a number of examples of each available instar; this was particularly important since, to begin with, nothing was known of the number of instars, their appearance, sexual differences in the young, or even the identity of many examples. The latter differed so greatly from the adult, or so resembled the young of various species in a single genus, that they had to be reared and only the exuviae preserved. Detailed descriptions and pattern sketches of the young were particularly important since evanescent color patterns are proving exceedingly helpful in working out phylogenetic relationships.

Drawings. Sketches of displays and color pattern were made from the living spider, the exact proportions being worked out from preserved examples. All display drawings were completed in the field, so that final details could be checked from other displaying individuals.

Attention may be called here to an excellent technique recently reported by Dr. Kaston (1948, p. 47), giving credit to Miss Kathryn Sommerman. Palps and other parts may be easily held for hours in any desired position by first placing a bit of vaseline in the bottom of the dry observation dish. The specimen is then partly imbedded before alcohol is flowed in.

Study of Exuviae. The cast skins are best preserved dry, each in a separate vial with a bit of absorbent cotton. They become entangled in the strands just enough to cling when the cotton is removed with forceps. They can be repeatedly taken out for study, comparison and drawing, without damage and with minimum danger of being blown off the stage by an unwary breath. Yet the tangling is so slight that they can be easily manipulated, or legs and other parts detached at will and mounted for high-power study.

Preservation. Except for exuviae, all specimens are preserved directly in 70% alcohol. Early instars needing repeated removal from vials during study are also best tangled in a few strands of cotton.

Display Observation. Fortunately, the displays of a number of the reared species, belonging to widely separated genera, were observed in the field, in various degrees of completeness. In every case, the threat and courtship display behavior was identical with that recorded under laboratory conditions. Some of the experiments were also repeated successfully, using uncaptured spiders in their natural environment; the results of these corresponded closely to those in the laboratory. They will be described in detail in subsequent reports. The important point here is that captivity has no apparent effect on the display behavior patterns of salticids.

The most convenient vessel for display study in the laboratory is a shallow glass dish, measuring at least 4 × 4 × 2″ and covered with a piece of window glass. The aeration system described by the Peckhams (1889, p. 37) is unnecessary in these studies, since the spiders are kept in the dishes for a few hours at most. Transfers from jar to dish are made with a 3 × 1″ vial, the spider being gently prodded when necessary with a camel's hair brush. Spiders in display condition (see below) never need more than a

few minutes to settle down in their new surroundings. The glass dishes are particularly suitable for experiments, since they can so easily be scalded, wiped with alcohol and aired, in order to remove chemical traces of previous occupants.

A simpler display study technique is applicable to some salticids which, while having especially good eyesight, depend relatively little on chemotactic and/or smell stimuli. Their displays may be studied on an open table, the danger of persistent chemotactic stimuli being eliminated by using a fresh sheet of white or light-colored paper for each test. Various tints of blue, green, yellow and gray made no perceptible difference in the responses. These spiders, of which examples are *Corythalia, Eustiromastix, Mago* and *Hypaeus*, are all highly developed literal jumpers; even their normal progress is usually a series of hops, and they are invariably less restless—to human eyes less "nervous" —than other groups of the family. Their attention is easily attracted by appropriate visual stimuli and, even in the absence of a stimulus, they do not tend to race off and get lost in a frenzy of multisensory exploration.

The dish-study method will, however, be found to be more practicable for the majority, at least of tropical salticids, which are runners except during the emergencies of hunting and of progress over chasms. These genera include *Semorina* and other ant-like salticids, *Menemerus, Ashtabula* and *Sassacus*. This subject of basic behavior variation will be fully discussed in a subsequent paper.

During observation in both field and laboratory, magnifying spectacles were most useful; they consisted of small lenses, about ×5, mounted several inches in front of empty frames.

When unfamiliar males and females were taken, trial-and-error was the only way of determining, while they were still alive, whether they belonged to the same species. Members of the *Phidippus* and *Plexippus* groups are particularly difficult since not only is sexual dimorphism aften extreme but also the females are frequently voracious. Extreme vigilance failed to prevent all accidents when I guessed wrong and placed together a male and female of different species. Yet the risk was worthwhile, because sometimes only a single adult pair of a given species in breeding condition was taken during the season. For example, in 1945 the only adult male *Eustiromastix* was kept alive for three months and tried with four different kinds of females before the right one, caught in an early instar, finally molted to the adult form and stimulated the male to display.

In most species, as Bonnet (1933) found with *Philaeus*, there is little danger of cannibalism so long as the spiders are well fed. Our specimens were always given flies not more than 24 nor less than three hours before display experiments.

A vital factor in spider experiments, as in those with other animals, has proved to be the fluctuating physiological condition of both sexes. The only part of this subject which belongs properly in this account of methods is the fact that its influence must always be kept in mind by the investigator. A male taking no interest in a certain female on one day may display and mate promptly with her twenty-four hours later, under conditions as exactly similar as it is possible to make them. Also, the behavior of a male not in top display condition is often not typical of the species; for this reason salticids are best studied when at their physiological peak, that is, when their threshold to display stimuli is low. Under natural conditions it is usually only males in this condition which have sufficient persistence to carry through display to successful mating. Therefore, unlike many vertebrates (cf. Tinbergen, 1948, p. 39), the most easily stimulated spiders give the most typical responses; concomitantly, positive reactions of these individuals to incomplete or abnormal stimulus situations should not be underestimated in determining the relative importance of various releasers.

In discovering the condition of a given male, for use in experiments concerning sign stimuli, one or two stimuli were presented, with known effects on his particular species in different physiological states. For example, a mirror was moved in a certain way for a certain length of time and/or a particular mounted specimen was similarly manpulated. During a series of experiments the condition of the spider must be frequently rechecked by these standards, especially in the case of negative responses. For instance, if a male will not display to a new mount (see below) with a white spot painted on the clypeus, his condition must be rechecked immediately with the standard stimuli, since the spiders tire and/or become overstimulated very suddenly and completely.

This brings up the point of rest periods, the importance of which has been recently reemphasized by Tinbergen in regard to vertebrates (idem, p. 43). It is essential to rotate the members of the test group during each experimental session, in order to avoid the after-effects of stimulation. This principle has been observed in all the experiments with Rancho Grande salticids.

The above remarks have applied equally well to the study of typical display patterns of salticids and to experiments performed to determine their innate releasing mechanisms. The following paragraphs give a survey of general methods used in strictly experimental work. In subsequent papers details of particular experiments will be given where advisable, to substantiate the validity of certain conclusions.

General Position of Experimental Table. In order to minimize possible effects of phototropisms, the observer always sat with back to the window. All experiments concerning releasing mechanisms were con-

ducted in daylight, within a certain range of temperature, brightness and humidity.

Mounted Specimens. L-shaped pieces of cardboard, such as may be cut from library cards, are very useful in experimental work. Individual spiders are chloroformed and at once fastened with glue or paper cement to the short arm, in any desired position. The color of the card is immaterial if it is a fairly light tint, and so contrasts in brightness with the spider. Whether or not it matches the background of the table over which it is manipulated has no apparent effect: a test spider never responds to an L alone. However, to reduce the variables, the procedure was standardized, to use only light green cards on a background of similar hue, brightness and saturation. The tip of the long end is bent up to form a convenient handle. A number is written on the card, and the whole dried (in order to eliminate odor stimuli), protected from pests by paradichlorobenzine crystals; odors from the latter are quickly dissipated before experiments, and in any case have no apparent effect on the subjects. Such a mount becomes a standard and can be used indefinitely. When it is manipulated before a test spider, the latter takes no notice of either the observer's hand, which is usually behind him anyway, because of the length of the L-arm, or of the L itself; his attention, if any, is captured only by the mount. L-cards are also useful in manipulating lightly chloroformed spiders, for example females, where it is desired only to test the effect of her odor as opposed to chemotactic stimuli; the card insulates her from the background, so that she does not leave a "trail" during the manipulations. Finally, painted cardboard models of spiders are likewise glued on L-cards for ease of hand'ing and storing.

Anaesthesia. Ether, refrigeration and chloroform have been tested, and of the three chloroform is the most satisfactory. Recovery from ether is too quick, whether the specimen is anaesthetized for testing reactions to immobility of another individual, or for painting or mutilating; also, ether itself is often highly disagreeable to the observer. Recovery from refrigeration is almost instantaneous or, if it has been prolonged in a tropical spider, normal behavior may never be resumed. A special cold technique, however, is sometimes preferable to chloroform during a long operation: the spider is first chilled to immobility in the refrigerator, then promptly brought to the microscope and the work performed on top of a cheesecloth-wrapped ice cube. Recovery of complete display reactions can never be assured by this means.

Chloroform, when handled carefully, is the most satisfactory anaesthetic. For moderately swift recovery with unimpaired reactions, the spider should be placed in a vial with a chloroform-dipped cork; there it should stay just long enough to make its legs go rigid *after* its removal from the fumes; that is, it should be taken out before stupor appears complete. In the case of a long operation, several repeated short doses of chloroform are better than a single long one. Different salticid species, even when closely related and of similar size, vary considerably in their reactions to the various methods. The use of carbon dioxide is a possibility still to be tested in this group.

Paint. A number of different kinds of paint were tested for marking and altering patterns in salticids. Uniformly satisfactory for all indoor experimental work except blinding were opaque water colors. In blinding, a base coat of the above water color was given, followed by an overcoat of light-colored Flopaque paint (see below) or even fingernail polish. The base coat is necessary to insulate the spider against harmful effects of the strong chemical varnishes and their removers; the spider may die if paint is allowed to seep around the eye margins; more important, the powerful removers are invariably poisonous. The base coat of water color is stuck with difficulty on the shiny convex surfaces and is easily removed by the spider if not covered with the more adhesive paint; however it is completely harmless, protects the margins from the covering paint, and both layers are sponged off easily and simultaneously with a water-soaked brush. Light colors are used so that complete eye-coverage may be easily checked. Shellac, used by the Peckhams and others, seems to share difficulties with other non-water-colors: although it is not necessarily poisonous in itself and will largely wear off in time, turpentine or other removers are harmful; the importance of this lies in the technique of modern experiments, since a negative reaction, for validity, should be promptly supported by positive reactions to the same stimuli after sight has been restored, to eliminate the factors of post-operative or post-anaesthetic effects.

Water color obviously will not serve for marking spiders to be liberated. For this purpose Flopaque paint (manufactured by Floquill Products, Inc., New York 23, N. Y.), is ideal. It is waterproof, dries almost instantly, and adheres well to either scales or naked chitin. Also, it is thinner than any insect-marking mixture I have tested, so that a variety of identification patterns are easily painted. It is harmless to the spider when applied on top of either carapace or abdomen, but all appendage joints, especially near the body, as well as the eye margins, should be avoided.

Cards were painted with samples of various tints and shades of the opaque water colors, as well as colors straight from jars. These were used to determine their relative brightness with a Weston exposure meter. A similar set of cards with grays of corresponding values, as well as whites, was then made up. Finally the cards were photo-

graphed through a filter (Wratten No. 18A) reflecting substantially all rays except the ultra-violet, in order to determine which of the colors involved an ultra-violet factor; the reds were also tested visually through a blue-green filter for blue and violet content. Obviously these tests can give only approximate results; their value lies in preliminary color vision studies in a field laboratory, in the absence of precision instruments.

In regard to the actual painting technique, nothing need be said except that even the finest paintbrush obviously must be trimmed to paint a successful spot on a half-millimeter clypeus. The spider is best held on the dissecting microscope stage in the bare fingers, but protected by an enfolding wisp of cotton.

Mutilations. A dissecting needle with a tiny distal blade is ideal for quickly removing palps or legs at any desired joint, or for shaving off hairs and scales.

Distance Measurements. Distances at which reactions to a stimulus were initiated were measured conveniently as follows: A piece of green oilcloth was marked with black ink into 12 numbered, concentric circles an inch apart. The whole was varnished with an alcohol-proof preparation, so that chemotactic trails could be removed with alcohol after every use. A sheet of glass might be used, instead of varnish.

V. Summary.

This paper is devoted primarily to methods of studying salticid spiders alive in the tropics. Shaking, visual searching, and examination of airplants are the primary collecting methods. Dry season fauna is scanty, even in rain forests. Specimens are maintained and reared successfully in small jars with mosquito netting tops. Continuous but non-constant moisture is supplied with dampened, cotton, dental wads. Food consists of *Drosophila* and other small flies, reared and wild. Second instar young are fed small leaf litter organisms and de-winged *Drosophila*. Displays are studied in natural habitats, on open tables and in glass-covered dishes. Colors and display positions are recorded from living specimens. Dried or chloroformed examples, for experimental manipulation, are conveniently mounted on the short ends of L-shaped pieces of cardboard. Chloroform, carefully controlled, is a successful anaesthetic. Color and pattern are usually altered with opaque watercolors. Mutilations are performed with a bladed needle. Painted, concentric circles are convenient for measuring distances of responses to stimuli. Precautions against confusion of experimental results are discussed, as well as the general suitability of salticids as subjects for experimental research.

VI. References.

Beebe, W., and Crane, J.

1947. Ecology of Rancho Grande, a subtropical cloud forest in northern Venezuela. *Zoologica*, Vol. 32, No. 5, pp. 43-60.

Bonnet, P.

1930. La mue, l'autotomie et la régénération chez les Araignées avec une étude des dolomèdes d'Europe. *Bull. Soc. His. Nat. Toulouse*, Vol. 59, pp. 237-700.

1933. Cycle vital de *Philaeus chrysops* Poda. *Arch. zool. exper.*, Vol. 75, pp. 129-144.

Branch, J. H.

1942. Notes on California spiders. I. On the culture of the spider *Teutana grossa* Koch. *Bull. S. Calif. Acad. Sci.*, Vol. 41, pt. 3, p. 138.

Brown, H. P.

1946. A technique for rearing spiders. *Turtox News*, Vol. 24, no. 4, p. 76.

Bryant, E. B.

1943. The salticid spiders of Hispaniola. *Bull. Mus. Comp. Zool., Harvard Coll.*, Vol. 92, No. 9, pp. 445-552.

Chickering, A. M.

1946. The Salticidae (spiders) of Panama. *Bull. Mus. Comp. Zool., Harvard Coll.*, Vol. 97.

Crane, J.

1948. Comparative biology of salticid spiders at Rancho Grande, Venezuela. Part I. Systematics and life histories in *Corythalia*. *Zoologica*, Vol. 33, No. 1, pp. 1-38.

Kaston, B. J.

1948. Spiders of Connecticut. *State of Connecticut Public Document No. 47; State Geological & Natural History Survey Bull.* No. 70, pp. 1-874. Hartford, Conn.

Moles, M. L.

1916. Growth and color patterns in spiders. *Jour. Entom. & Zool. Pomona Coll.*, Claremont, Calif.

Peckham, G. W. and E. G.

1889. Observations on sexual selection in spiders of the family Attidae. *Occ. Papers Wisconsin Nat. Hist. Soc.*, Vol. 1, pp. 3-60.

1890. Additional observations on sexual selection in spiders of the family Attidae. *Occ. Papers Wisconsin Nat. Hist. Soc.*, Vol. 1, pp. 117-151.

Tinbergen, N.

1948. Social releasers and the experimental method required for their study. *Wilson Bull.*, Vol. 60, No. 1, pp. 6-51.

Wagner, W.

1888. La mue des Araignées. *Ann. Sci. Nat.*, Ser. 7, Vol. 5, pp. 280-393.